ON THE

TAPETUM LUCIDUM

AND

THE FUNCTIONS OF THE FOURTH PAIR OF NERVES.

BY

HENRY LEE,

CONSULTING SURGEON TO ST. GEORGE'S HOSPITAL.

The Royal College of Surg
from the Author

ON THE
TAPETUM LUCIDUM
AND
THE FUNCTIONS OF THE
FOURTH PAIR OF NERVES.

BY

HENRY LEE,

CONSULTING SURGEON TO ST. GEORGE'S HOSPITAL.

C

LONDON:
PUBLISHED BY
J. & A. CHURCHILL, NEW BURLINGTON STREET.

1887.
PRICE ONE SHILLING.

INTRODUCTION.

THE following Essays were the results of two series of investigations conducted entirely independently of each other, and the relations between the two became apparent only as they approached completion.

In a dark passage the glare of a cat's eyes may be seen when nothing else is visible. The concentrated light is directed on the face of the observer, and may give him the first intimation of the cat's presence. This implies two things: first, that light does come from the cat's eyes; and, secondly, that the cat has the power of concentrating that light on any object that it may wish to see.

These two questions are dealt with in these papers which are now reprinted together from the "Royal Medical and Chirurgical Transactions" and from "The Lancet."

9, SAVILE ROW, W.

ON THE TAPETUM LUCIDUM.

BY

HENRY LEE,

CONSULTING SURGEON TO ST. GEORGE'S HOSPITAL.

[*From Vol. LXIX. of the "Medico Chirurgical Transactions," published by the Royal Medical and Chirurgical Society of London.*

NO satisfactory account has yet been given of the use of the tapetum lucidum, nor has its disposition in different animals been accurately described.

The tapetum has generally been examined after the eye has been removed from its socket. It is then difficult to replace it in its exact natural position, and it has consequently been generally loosely described as irregularly placed at the back, or outer part of the back of the eye.

In order to ascertain the exact position of the tapetum, in its relation to surrounding parts, it should be examined *in situ*, before the eyeball is removed. For this purpose the upper part of the orbit may be taken away, leaving the eye in its natural position. The anterior part of the eye, including the iris, must also be removed, any colouring matter that may have escaped from the choroid must be washed out with a thin stream of water, and the retina, which becomes opaque a few hours after death, must be removed in the same way. The tapetum will then be fully exposed, and the light reflected from its surface will be seen to have a very definite direction, adapted to the habits and instincts of the different classes of animals which possess it.

In the ox and in the sheep the tapetum is seen principally on the upper and outer part, in relation to the socket of the eyeball: whereas in the dog and the cat it is seen rather on the inner side.

The eyes in the ox and the sheep are placed on the sides of the head. In the lion, the dog, and the cat the eyes are placed more forward, and they can therefore use both eyes at once. In relation to the eyeball itself, the tapetum is found to occupy a different position in these different classes of animals. Taking the entrance of the optic nerve as a given point, the tapetum in the ox and in the sheep is seen principally on the upper and outer part. In the dog and the cat it is situated above the optic nerve and extends to about the same distance inwards and outwards.

The direction of the rays of light reflected from the tapetum is very remarkable. In the ox and in the sheep they are brought to an ill-defined focus; in the cat and the dog they are nearly parallel. This may even be observed without dissection. The reflection from the tapetum in a recently killed cat may be seen from the end of a room if the pupil be dilated. In the ox and in the sheep it can be best seen when the eye of the observer is near the animal's nose. When the anterior part of the eye, including the iris, is removed, the direction of the reflected rays becomes much more apparent, especially when the experiment is made some hours after the animal's death

Experiment I.—In a calf's head, the roof of the orbit was taken away and the anterior part of the eyeball removed behind the ciliary ligament. The vitreous humour, some pigment which had escaped, and the retina were washed away. The tapetum was now seen, accurately and sharply defined, to occupy exclusively the upper and outer quadrant of the posterior half of the eye, with the exception of a spur with a bulbous extremity which projected inward.* The tapetum had a bright metallic lustre, resembling mother-of-pearl. A light was now thrown on it in a room otherwise darkened, and the rays were reflected so as to be brought to an ill-defined focus about three inches to the outer side of the animal's nose. This focal concentration of light was very apparent on a black surface.

---

* This spur varies in shape in different specimens, and is better developed in the sheep than in the ox.

Experiment II.—A sheep's head was prepared in the same way as in the first experiment, and a light was thrown into the eye. The reflected rays from the tapetum were now found to come to the same kind of ill-defined focus, not on the side of the nose, but three or four inches in front of it.

In connection with these two experiments it is remarkable that the ox grazes from side to side; the sheep, forward.

Experiment III.—A cat was placed in a box with some chloroform. When it was dead, the pupils were found to be greatly dilated. The reflection from the tapetum could be seen in ordinary light from any part of a large room. It was visible, however, in one direction only, and that was in a line slightly diverging from the median plane laterally, and nearly parallel to the nose downward. The roof of the orbit was now removed and the anterior part of the eye taken away, as in the two former experiments. The reflection of light from the tapetum, which before was of a light yellow colour, now appeared of a very light green, of the brightest metallic lustre. The reflected rays of light did not here come to a focus as in the ox and the sheep, but were projected forwards and downwards, very much in the same direction as they were before the anterior part of the eye was removed. The tapetum was found to be situated altogether above the entrance of the optic nerve, extending nearly equally to its inner and outer side. It had a very sharp well-defined outline, about the size and shape of a longitudinal section of a kidney bean, with its slightly convex edge upward. In relation to the orbit the tapetum appeared in great part on its inner side, and could only be partially seen from the median plane.

Experiment IV.—A young cat was chloroformed; the nictitating membrane and the eyelids being removed, the bright yellow glare from the tapetum was seen with nearly the same brilliancy from any part of the room. The cornea, iris, and lens were now removed, and the tapetum was seen in this instance to be of a bright yellow lustre. It was on the inner side of the orbit, so that, viewed from the median line, the whole of it could not be seen.

These experiments have been repeated in various ways, always with the same general results.

In the horse the tapetum is very well developed, and that part which is to the inner side of the entrance of the optic nerve is larger than in the ox. When the anterior half of the eye is removed and the vitreous humour washed out, the reflection from the two portions of the tapetum is seen of a very bright lustre. The light, however, from the two portions is not reflected in the same direction, nor can both be well seen at once. That from the outer portion is directed downwards and inwards, as in the ox—that from the inner portion, downwards and forwards.

The reflection from the outer portion is best seen at about a foot distant: that from the inner is seen clearly at the distance of six feet.

The tapetum in the horse when spread out measures fully two inches in its transverse diameter. From its extent the reflected light is thrown over a larger area than in the ox, and the rays are not parallel to each other as in the cat.

This extended reflecting surface, with a prominent and moveable eye, must give the horse the assistance of a considerable range of vision in twilight (or, as it appears to us, in the dark) from reflected light.

In dogs the disposition of the tapetum is very much the same as in cats. The lustre has appeared not so bright as in cats, but brighter than in the ox.

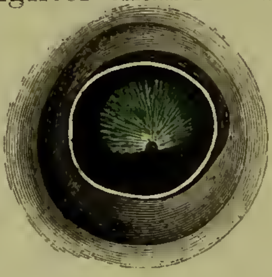

FIG. 1.

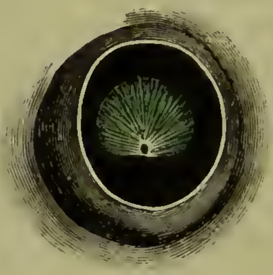

FIG. 2.

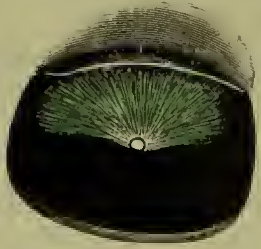

FIG. 3.

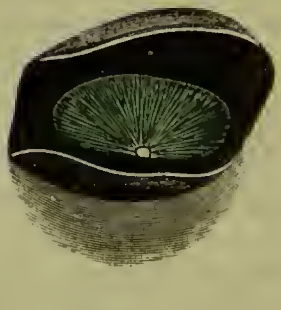

FIG. 4.

Figs. 1 and 2 represent the tapetum, *in situ*, in the two eyes of the same cat. They were necessarily drawn separately, as they could not be fully seen together without removing the nasal bones. Viewed from the front, where the whole of the tapetum could be seen, it appeared almost circular. The rays of light from the natural concave surface were reflected in nearly parallel lines within an area that would allow the whole to pass through a dilated pupil.

Figs. 3 and 4 represent the tapetum in two eyes of another cat, after they had been removed from their sockets. More of the anterior parts of the eyes had been removed than in those represented in Figs. 1 and 2. The tapetum in Figs. 3 and 4 is represented as it lay expanded on a flat surface. The transverse diameter therefore appears longer than it would in its natural concave position.

The ox and the sheep, having their eyes placed on the sides of the head, see an object accurately with one eye only. The dog, the cat, and the lion having their eyes placed more forward, can use both at once. If the tapetum in the cat had been placed on the outside of the eyeball, as in the ox, the rays of light reflected from its surface would have fallen on the nose, or crossed each other immediately above it. In any case the reflected light could have been thrown on the same object from one eye only at the same time, and that in a different direction to that which is required by the animal's instincts. On the other hand, if the tapetum of the ox had the same relative position as in the cat, it would be of little use as far as grazing is concerned.

The ox and the sheep have both very large pupils in the transverse diameter. All the rays of light reflected from the ground within a given area, which impinge upon the tapetum in these animals, are collected as from a concave mirror and again reflected in a concentrated form directly on their food. This provision must enable them to feed in the dim twilight with comparative comfort and safety from the admixture of foreign matter, alive or dead. The concave mirror situated within the eye itself acts the part of the concave mirror in an ordinary ear speculum.

In the daylight the pupil of the cat is often contracted to a mere line from above downward, but when the cat is excited the pupil becomes round and fully dilated. The glare of a cat's eyes when met in a dark passage has long been noticed, and from the fact that this is seen equally on both sides, it appears that the cat has the power of directing the reflected light from both eyes to the same object at the same time The degree of convergence of the optic axes may therefore give the cat the power of estimating accurately the distance of its prey before making its spring.

The glare of the lion's eye was not unknown to Shakespeare. In his description of the dreadful night on the eve of the ides of March, he makes Casca say :—

> "Against the Capitol I met a lion,
> Who glared upon me."

The tapetum is situated in front of the choroid and may be dissected off it, leaving the choroid of its natural colour. This colour, according to Hunter, presents in different animals every shade from nearly white to black. A coloured choroid may therefore be mistaken for a true tapetum.

Among the eyes that I have examined I have found that the tapetum does not exist in the hare, rabbit, rat, sea-gull, heron, plover, rook, common fowl, landrail, moorhen, hawk, owl,* Egyptian vulture *(Neophron pereopterus)*, &c. The tapetum does not exist in the eyes of any fish which I have been able to obtain.

The conclusions arrived at are :—

1. That where the tapetum exists, the eye has, by reflected light, an illuminating power.

2. That this power can be utilised only at comparatively short distances, and that the eyes of fish and of birds (which have the longest and keenest vision) have it not.

3. That in animals which possess the tapetum the light reflected from its surface is directed in different classes of animals respectively in accordance with the wants and instincts of each.

---

* The eyeball of the owl is peculiar ; it somewhat resembles a very small opera-glass. In common with the eagles and the hawks, the owl takes its food in its claws. Mice and rats generally take it in their fore paws ; rabbits and hares eat deliberately and slowly, and masticate their food as they take it. None of these require the assistance of a tapetum either in catching their prey or in avoiding any foreign matter that might accidentally be mixed with their food.

(For report of the discussion on this paper, see "Proceedings of the Royal Medical and Chirurgical Society," New Series, vol. ii., p. 50.)

ON THE FUNCTIONS

OF THE

FOURTH PAIR OF NERVES.

BY HENRY LEE,

CONSULTING SURGEON TO ST. GEORGE'S HOSPITAL.

(*Reprinted from the Lancet.*)

The fourth pair of nerves are distributed exclusively to the superior oblique muscles. They communicate with the third pair of nerves, and with the sympathetic in the cavernous sinuses. At their origin they decussate.* These relations indicate that they may act in sympathy with each other, conjointly, or in combination with the third pair of nerves. In the great majority of animals the muscles which they supply run transversely across the eyes and are opposed by muscles running in the same direction supplied by the third pair of nerves. Animals which have their eyes placed forward in the head offer an apparent exception to the general rule, and in these the muscles mentioned pass backward and outward, and have therefore been called

---

* College Prize Essay, by A. Woods.

"oblique." As the fourth pair of nerves supply only the superior oblique muscles, the function of the nerves and the muscles which they supply must be the same. When the superior oblique acts in conjunction with the inferior oblique of the opposite side, the two eyes move in concert and the eyes are rolled upon their axes. If the two oblique muscles act together with some corresponding action of the inferior obliques, their function is to compress the eyes laterally. In man, if one superior oblique only acted, the eye would be turned downward and outward. If both acted unopposed, both eyes would be turned downward and outward. This would give a very ungainly expression, and could be of no possible use. The real office of the superior oblique muscle is illustrated in its disposition in the eyes of the vast majority of the lower animals. In them the two transverse muscles embrace the eye, and the only action that they can have in all animals, when acting with equal force, is to compress the eyeball. For, although in some animals, from their oblique direction they might be supposed to influence the directions of the eye, this could not be the case in others. In the swan, for instance, the so-called superior oblique muscle runs directly across the eye in its transverse diameter. From the observation of the action of this muscle in man, its use has been assigned by no ordinary authority to be that of "raising and dragging the eye in conjunction with the changes to which the other features are subjected in bodily pain, in agony of mind, and in all this class of passion." * But not to mention that there are whole classes of animals in whose features no such expressions are ever recognised, the disposition of this muscle in fish and birds entirely forbids the idea of any such office being assigned to it. It may therefore be concluded that the oblique muscles, taken together, have a two-fold action: first, that of rolling the eye; and secondly, that of compressing it so as to alter its focal length. This affords a means of adjusting the eye of the vision of near objects, and may be regarded as the most powerful mode of adjusting the visual axis of the eye, while the mechanism for the finer adjustment is within the eye itself. The two oblique muscles taken together, then, have a double function, and a double and separate supply of nervous power.

Dr. Hosack, in a paper published in the Philosophical Transactions in 1794 (part 11, p. 222), observed that external

---

* Charles Bell.

pressure was capable of altering the focal length of the eye, so as to adapt it to vision at different distances. "With a speculum," he says, "I made pressure upon my eye while directing attention to an object twenty yards distant, and saw it distinctly: but, endeavouring to look beyond it, everything appeared confused. I then increased the pressure considerably, in consequence of which I was able to see objects distinctly at a much nearer than the natural focal distance. For example, I held a book before my eye at the distance of two inches. In the natural state of the eye I could neither distinguish lines or letters, but on making pressure with the speculum I was enable to distinguish both with ease." Dr. Porterfield * objects to this explanation—that in the jack the oblique muscles "are both situated on the under side of the eye, where they decussate each other in the form of a cross"; and he therefore argues that the disposition of these muscles is not such as to allow them to compress the globe of the eye: "Had they been so disposed as to embrace the globe in the form of a ring, their contraction might then have squeezed the eye into an oblong form." Having repeatedly dissected the eye of the jack, the author is enabled to assert positively that the oblique muscles have the very disposition which Dr. Porterfield is here contemplating. His assertion respecting their decussation below the eye has evidently arisen from his mistaking the inferior rectus for one of the oblique muscles.

A case, indeed, has been quoted in text-books in which all the muscles applied by the third pair of nerves were paralysed, and a good accommodation remained. † An inference is drawn from this case that the recti and obliqui muscles have really very little power in producing this accommodation. But in this case the fourth nerve was not paralysed; and inasmuch as the peculiar function of the fourth nerve is to regulate the degree of compression exercised on the eyeball by the superior oblique muscle, the case affords additional evidence of the real function of this nerve. In seals the fourth pair of nerves is well developed. The visual focal length would be different in them in the air and in the water for correct vision, and yet a seal can catch a fish as accurately out of the water as in it. The development of the fourth pair of nerves here corresponds with its power of adaptation of the eye to accurate vision under different circumstances. In the monkey again, where

---

* Porterfield on the Eye, Vol. I., p. 424, *et seq*

† Power on the Eye, p. 592.

accuracy of vision, in jumping from branch to branch, is so necessary, the fourth pair of nerves is well developed. In the cat, which measures its distance accurately before making its spring, the fourth pair of nerves is also well developed. But here, as in other animals which have a *tapetum lucidum*, the nerves and the muscles which they supply have another function. They not only regulate the antero-posterior diameter of the eye for the reception of light entering the eye, but also focus the light reflected from the *tapetum lucidum*.* The power of concentrating reflected light accurately upon an object must give the animal the same knowledge of distance as the focus obtained in ordinary vision. In the flaccid eye of a dead cat the rays of light reflected from the tapetum are nearly parallel. If the antero-posterior diameter of the eye were altered in a living cat, as by the action of the oblique muscles, the rays of reflected light after they had left the eye would converge as they do in the larger eyes of the sheep and the ox ; the degree of the action of the oblique muscles in bringing the reflected rays to a focus would then afford an indicatfon of the distance of the object looket at. The amount of convergence of the two optic axes in binocular vision plays, no doubt, a much more important part in the measurement of distance. But by far the larger majority of animals which have a tapetum use one eye only at a time. Where the two eyes are used togethor the degree of convergence is under the control of the external rectus, which, like the superior oblique, is supplied by a separate nerve.†

Those who have called a policeman's lantern a "bull's-eye" have never realised the analogy that exists between the lantern and the real eye. The glare from the anterior surface of the cornea may have originated the name. In the living eye the rays of light reflected from the tapetum may, within certain limits, be concentrated upon any given spot, and the light thus concentrated, as may be illustrated by a slightly concave mirror, is very much more intense than that produced by ordinary scattered rays. If a policeman's lantern were constructed with a slide so that the distance between the light and the reflector could be regulated, the analogy would be more perfect. The rays of light might than be brought to a focus instead of always being directed in parallel lines.

---

* Med.-Chir. Transactions, Vol. lxix.

† The advantage of judging of distances in binocular vision has probably some compensation in animals, which use only one eye at a time. The more perfect grasp of the eye by the transverse muscles must enable them to focus the rays of light more perfectly than in animals in which the muscles are oblique. The owl, unlike other birds, has its eye placed forward. This disposition enables it to direct both eyes to the same object at the same time. It has therefore the advantage of binocular vision. In common with other animals which seek their prey at night, it has within a limited distance the power of judging of the position of objects by the angle at which the visual axes meet.

In ordinary carriage lamps the light is thrown straight forward, which, no doubt, is an advantage to the driver; but for the horse itself the light is required where their natural reflectors throw it—namely, in front of their feet. In the transmission and reflection of light through the transparent parts of the eye some light is necessarily lost. If the whole of the light were reflected from a concave mirror three inches square, and concentrated in a focus of one inch, that inch would receive its natural proportion of ordinary light and nine times the amount of light falling upon each square inch of the mirror.

BY THE SAME AUTHOR.

PRACTICAL PATHOLOGY.

Third Edition, in Two Vols.

J. & A. CHURCHILL, NEW BURLINGTON STREET